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(21) International Application Number: <b>PCT/BE97/00084</b> (22) International Filing Date: 15 July 1997 (15.07.97) (30) Priority Data: 96870092.2      15 July 1996 (15.07.96)      EP (34) Countries for which the regional or international application was filed: AT et al. 96870121.9      19 September 1996 (19.09.96)      EP (34) Countries for which the regional or international application was filed: AT et al. (71) Applicant (for all designated States except US): UNIVERSITE LIBRE DE BRUXELLES [BE/BE]; Avenue F.D. Roosevelt 50, B-1050 Brussels (BE). (72) Inventors; and (75) Inventors/Applicants (for US only): GOURLET, Philippe [BE/BE]; Avenue Guillaume Stassart 103, B-1070 Brussels (BE). ROBBERECHT, Patrick [BE/BE]; Avenue de Visée 65, B-1170 Brussels (BE). VANDERMEERS, André [BE/BE]; Avenue du Pesage 9, B-1050 Brussels (BE). WOELBROECK, Magali [BE/BE]; Rue Démosthène 63, B-1070 Brussels (BE).		(74) Agents: VAN MALDEREN, Eric et al.; Office Van Malderen, Place Reine Fabiola 6/1, B-1080 Brussels (BE). (81) Designated States: CA, JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published Without international search report and to be republished upon receipt of that report.																																																																																																																																																																												
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(57) Abstract <p>The present invention is related to a peptidic ligand having a higher selectivity for the VIP<sub>1</sub> receptor than for the VIP<sub>2</sub> receptor. The present invention is also related to the diagnostic device, the pharmaceutical composition comprising said ligand and to their use.</p>																																																																																																																																																																														

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10 PEPTIDIC LIGANDS HAVING A HIGHER SELECTIVITY FOR THE VIP<sub>1</sub>  
RECEPTOR THAN FOR THE VIP<sub>2</sub> RECEPTOR

Field of the invention

The present invention is related to new peptidic ligands having a selective affinity for the VIP<sub>1</sub> receptor and to the pharmaceutical composition comprising them. The present invention is also related to the use of said compound and said composition as therapeutic agent, specially in the treatment of bronchoconstrictive disorders. The present invention is also related to said ligands of VIP<sub>1</sub> receptor being labelled, and incorporated into a diagnostic device which could be used in imagery or as diagnostic tool.

Background of the invention

25 The study of structure-activity relationships of Vasoactive Intestinal Polypeptide (VIP), Pituitary Adenylate Cyclase Activating Polypeptide (PACAP) and secretin has revealed the existence of domains responsible for high affinity binding, coupling to the effector system and discrimination between receptor subclasses.

- a) The N-terminal sequence is required for a high affinity binding as well as for an efficient coupling to the effector (1-10).
- b) The C-terminal sequence is also necessary for a high affinity binding [11]. However, C-terminally truncated peptides which retain the ability to bind to the receptors have a full biological activity.
- c) The central part (10-21) is usually considered as a spacer domain adopting a  $\alpha$ -helical conformation [12,13] and the side chains of the central residues, as not essential for receptor binding (11-13).

Variant VIP synthetic analog peptides including cyclic VIP analog peptides were described in the US Patent US-5234907 and in the European Patent Applications EP-0405242 and EP-0536741.

Vasoactive Intestinal Polypeptide (VIP) effects are mediated by high affinity Gs protein coupled receptors. The molecular cloning revealed the existence of two distinct VIP receptors with seven transmembrane helices named the VIP<sub>1</sub> and the VIP<sub>2</sub> receptors (26-30).

VIP<sub>1</sub> and VIP<sub>2</sub> receptors are pharmacologically distinct : the VIP<sub>2</sub> receptor had a higher affinity than the VIP<sub>1</sub> receptor for helodermin and a lower affinity for secretin and GRF (31).

The ligand RO 25-1553 is a long-acting Vasoactive Intestinal Polypeptide (VIP) agonist developed by O'Donnell et al. from Hoffman-La Roche.

The resulting cyclic peptide with a lactam ring between position 21 to 25 was reported to exhibit a high potency, metabolic stability and a long duration of action. In addition to its potent relaxing effect on guinea

pig tracheal smooth muscle and on isolated human bronchial preparations (1), RO 25-1553 also suppresses various pathophysiological features associated with pulmonary anaphylaxis and asthma including airway reactivity, oedema  
5 formation and granulocyte accumulation.

#### Aims of the invention

The present invention aims to provide new ligands having improved selectivity and affinity for the  
10 VIP<sub>1</sub> receptor, a diagnostic device and a pharmaceutical composition comprising said ligands, possibly labelled.

A further aim of the invention is to provide new ligands which may be used as therapeutic agent, especially in the treatment of bronchoconstrictive  
15 disorders (such as asthma, COPD), of tumours (neuroendocrine tumours, gastroenteropancreatic tumours, colon tumours) and of myocardial infarctions and strokes, the regeneration of the nerves as in post-traumatic injury, as anti-inflammatory and anti-oxidant agent, for the  
20 increasing of cells growth, as immuno-modulation agent in the treatment of auto-immune diseases and for reducing side effects in organs transplantation.

Another aim of the invention is to use said specific ligands in a diagnostic device for the  
25 identification of specific cancers such as breast and prostate cancers, lung cancers, ovarian cancers, colon cancers, etc.

Another aim of the invention is to provide a tool which allows the identification of other ligands of  
30 VIP<sub>1</sub> receptor, which could be used in the treatment and/or the prevention of the above-identified diseases.

A last aim of the invention is to provide a diagnostic device which comprises said labelled ligands and which may be used in the imagery or as a diagnostic tool in order to improve the diagnostic and/or to measure the evolution of the above identified disease.

#### Summary of the invention

The present invention is related to a new peptidic ligand which presents a high selectivity for the VIP<sub>1</sub> receptor, preferably the mammalian VIP<sub>1</sub> receptor, more preferably the human VIP<sub>1</sub> receptor.

"High selectivity for the VIP<sub>1</sub> receptor" means that the ligand according to the invention is more selective for the VIP<sub>1</sub> receptor than for the VIP<sub>2</sub> receptor, and that said selectivity is 10-fold more important for the VIP<sub>1</sub> than for the VIP<sub>2</sub> receptor, preferably 100-fold more important for the VIP<sub>1</sub> than for the VIP<sub>2</sub> receptor, more preferably 1000-fold more important for the VIP<sub>1</sub> than for the VIP<sub>2</sub> receptor.

Advantageously, the ligand according to the invention presents in position 16 (R<sub>16</sub>) a basic amino acid, preferably the Arginine (Arg). Preferably, said ligand presents also in position 4 (R<sub>4</sub>) an amino acid chosen from the group consisting of Ala, Gly, D-Ala or D-Phe.

The position of the amino acids of the various peptidic ligands according to the invention is compared to the general formula of the known agonists of the VIP receptor(s) as described in the publication of Christophe J. et al. ("Peptidic Hormones as Prohormones : Processing, Biological Activity, Pharmacology". Ellis

Horwood Limited, Chichester (Jean Martinez Ed.), pp. 211-243 (1989)).

The nomenclature used to define the peptidic ligands according to the invention is that typically used  
5 in the art wherein the amino group of N-terminus appears to the left and the carboxyl group at the C-terminus appears to the right.

The one-letter or three-letters amino acid symbol are the ones of the IU-PAC-IUB Biochemical  
10 Nomenclature Commission.

The peptidic ligand according to the invention can be an agonist, an antagonist or a reverse agonist of the VIP<sub>1</sub> receptor.

Preferably, said ligand is an agonist wherein  
15 R<sub>1</sub> = His, R<sub>2</sub> = Ser, R<sub>3</sub> = Asp, R<sub>4</sub> = Xaa, Ala, D-Ala or Gly, R<sub>5</sub> = XAA, R<sub>6</sub> = Phe, R<sub>7</sub> to R<sub>9</sub> = Xaa, R<sub>10</sub> = Tyr, R<sub>11</sub> to R<sub>14</sub> = Xaa, R<sub>15</sub> = Lys, R<sub>16</sub> = Arg, R<sub>17</sub> to R<sub>22</sub> = Xaa, R<sub>23</sub> = Leu, R<sub>24</sub> to R<sub>25</sub> = Xaa, R<sub>26</sub> and R<sub>27</sub> = Xaa or are deleted. Preferably, said agonist is the PG-97-268, which  
20 is a synthetic VIP/GRF analog, and having the formula H-S-D-A-V-F-T-N-S-Y-R-K-V-L-K-R-L-S-A-R-K-L-L-Q-D-I-L-NH<sub>2</sub>.

Preferably, said agonist presents also a high affinity to the VIP<sub>1</sub> receptor, which is shown by its IC<sub>50</sub> value for the human VIP<sub>1</sub> receptor.

Advantageously, the IC<sub>50</sub> value of said  
25 agonist for the VIP<sub>1</sub> receptor is ≤ 30 nM, preferably ≤ 5 nM. More preferably, the IC<sub>50</sub> value of the agonist according to the invention is compared to the IC<sub>50</sub> value of the VIP ligand for the VIP<sub>1</sub> receptor.

According to another embodiment of the present invention, the peptidic ligand is an antagonist wherein  $R_1 = \text{Ac-His}$ ,  $R_2 = \text{D-Phe}$ ,  $R_3 = \text{Asp}$ ,  $R_4 = \text{Xaa}$ , Ala, D-Ala or Gly,  $R_5 = \text{Xaa}$ ,  $R_6 = \text{Phe}$ ,  $R_7$  to  $R_9 = \text{Xaa}$ ,  
5  $R_{10} = \text{Tyr}$ ,  $R_{11}$  to  $R_{14} = \text{Xaa}$ ,  $R_{15} = \text{Lys}$ ,  $R_{16} = \text{Arg}$ ,  $R_{17}$  to  $R_{22} = \text{Xaa}$ ,  $R_{23} = \text{Leu}$ ,  $R_{24}$  to  $R_{25} = \text{Xaa}$ ,  $R_{26}$  and  $R_{27} = \text{Xaa}$  or are deleted. Preferably, said antagonist is the PG-97-269 having the formula  $\text{Ac-H-(D-Phe)-D-A-V-F-T-N-S-Y-R-K-V-L-K-R-L-S-A-R-K-L-L-Q-D-I-L-NH}_2$ .

10 The above-identified agonist or antagonist comprise 27 amino acids or less.

Advantageously, said antagonist presents also a high affinity for the  $\text{VIP}_1$  receptor, measured by its  $\text{IC}_{50}$  value for the  $\text{VIP}_1$  receptor, which is measured by its  $\text{IC}_{50}$   
15 value for the  $\text{VIP}_1$  receptor which is  $\leq 100 \text{ nM}$ , preferably  $\leq 50 \text{ nM}$ .

Preferably, the  $\text{VIP}_1$  receptor above-described is a mammalian receptor, preferably a human receptor.

The Inventors have tested in vitro the  
20 capacity of ligands to occupy the different  $\text{VIP/PACAP}$  receptor subclasses and to stimulate or inhibit adenylate cyclase activity. The cellular models tested expressed one single receptor subtype : Chinese hamster ovary (CHO) cells transfected with the rat recombinant  $\text{PACAP I-}$ , rat  $\text{VIP}_1-$ ,  
25 rat  $\text{VIP}_2-$ , rat secretin receptor and human  $\text{VIP}_2$  receptors; LoVo cells expressing the human  $\text{VIP}_1$  receptor. The agonist PG-97-268 had  $\text{IC}_{50}$  values of binding of 1, 10000, 10000 and 30000 nM for the rat  $\text{VIP}_1-$ ,  $\text{VIP}_2-$ , secretin and  $\text{PACAP}$  receptors, respectively. It showed an  $\text{IC}_{50}$  of 0.8 nM for



the human VIP<sub>1</sub> receptor and a low affinity for the human VIP<sub>2</sub> receptor. The analog stimulated maximally the adenylate cyclase activity on membranes expressing each receptor subtypes.

5                   The antagonist PG-97-269 had IC<sub>50</sub> values of binding of 10, 2000, 2 and 3000 nM on the rat VIP<sub>1</sub>-, VIP<sub>2</sub>-, human VIP<sub>1</sub>-, VIP<sub>2</sub>- receptors, respectively. PG-97-269 had a negligible affinity for the PACAP I receptor subtype. It did not stimulate adenylate cyclase activity, but inhibited  
10 competitively effect of VIP on the VIP<sub>1</sub> receptor mediated stimulation of adenylate cyclase activity with K<sub>i</sub> values respectively of 15 and 2 nM for the rat and human VIP<sub>1</sub> receptors. Thus PG-97-268 is a highly selective agonist ligand for the VIP<sub>1</sub> receptor and PG-97-269 a highly  
15 selective antagonist ligand.

The present invention concerns also the ligand according to the invention which is labelled, preferably by a radio-active compound such as radio-active iodine.

20                   The above representative ligands may be readily synthesised by any known conventional procedure for the formation of a peptide linkage between amino acids, including for example any solution phase procedure permitting a condensation between the free alpha amino  
25 group of an amino acid residue thereof having its carboxyl group or other reactive groups protected and the free primary carboxyl group of another amino acid or residue thereof having its amino group or other reactive groups protected.

30                   The process of synthesising the representative ligands may be carried out by a procedure

whereby each amino acid in the desired sequence is added one at a time in succession to another amino acid or residue thereof or by a procedure whereby peptide fragments with a desired amino acid sequence are first synthesised  
5 conventionally and then condensed to provide the desired peptide. Said conventional procedure for synthesising the novel ligand of the present invention include for example any solid phase peptide synthesis method. The synthesis of the ligands can be carried out by sequentially  
10 incorporating the desired amino acid residues one at a time into the growing peptide chain according to the general principles of solid phase methods [Merrifield, R.B., J. Amer. Chem. Soc. 85, 2149-2154 (1963); Brany et al, The Peptides, Analysis, Synthesis and Biology, Vol. 2, Gross,  
15 E. and Meienhofer, J. Ads. Academic Press 1-284 (1980)].

Said ligands may also be protected by various reactive product as described in the European Patent Application EP-0405242 incorporated herein by reference.

The new ligands of the present invention have  
20 also improved pharmacological properties and can be used as therapeutic agents.

The new ligands of the invention are preferably used for the treatment of bronchostrictive disorders such as asthma, COPD (Chronic Obstructive  
25 Pulmonary Disease). Said ligands may also be used for the treatment of various tumours, preferably chosen among the group consisting of (neuro)endocrine tumours, gastroenteropancreatic tumours as in vipoma and colon tumours. Indeed, it is possible to use said ligands as  
30 antagonists for the inhibition of tumours growth in the VIP<sub>1</sub> receptor expressing tumours.

In addition, the new ligands have protecting effects in ischemia and vascular diseases and may be used as therapeutic agent in myocardial infarctions and strokes.

The new ligands according to the invention  
5 may also be used in gastroenterological diseases having dysfunctions of motility, for the regeneration of the nerves, especially in post-traumatic injury, for their anti-inflammatory and anti-oxidant effects, and may therefore be used as anti-inflammatory and anti-oxidant  
10 compounds.

In addition, the new ligands according to the invention may also be used for increasing the cells growth (as therapeutic agent for cicatrisation) and for the immuno-modulation of specific blood cells (as therapeutic  
15 agent against auto-immune diseases and for reducing the side-effects of organs transplantations).

Another aspect of the present invention is related to a pharmaceutical composition comprising the ligands according to the invention and a (non-toxic inert)  
20 therapeutically acceptable carrier material. Therefore, the new ligand according to the invention may be combined with various adequate pharmaceutical carrier to provide composition suitable for use in the treatment of bronchoconstrictive disorders such as asthma. An effective  
25 dosage can be determine by one of ordinary skill in the art from the effective concentration disclosed herein. The ligand according to the invention can be used in addition to various salts such as inorganic or organic acids such as sulphuric, phosphoric, hydrochloric, hydrobromic,  
30 hydroiodic, nitric, sulphamic, citric, lactic, pyruvic, oxalic, maleic, succinic, tartaric, cinnamic, acetic, trifluoroacetic, benzoic, salycylic, gluconic, ascorbic,

and related acids. The present invention and the composition according to the invention may be administered by parenteral application either intravenously, subcutaneously, intramuscularly, orally, or intranasally.

5           The present invention is also related to a diagnostic device, such as a diagnostic kit, which may comprise the ligand according to the invention, especially the labelled ligand above-described.

Said device is used to identify the above-  
10 mentioned diseases or used as specific tumours marker such as neuroendocrine, gastroenteropancreatic and colon tumours, the breast and prostate cancers for metastases, the lung cancer, the ovarian cancer, the adenocarcinomas expressed in colon cancer, the squamous cell carcinomas,  
15 . . . .

The present invention is also related to the use of an effective amount of a selective ligand (selective agonist, antagonist or reverse agonist) of a VIP<sub>2</sub> receptor as an immunosuppressive and/or anti-inflammatory active  
20 compound, preferably for the preparation of a medicament for the treatment and/or the prevention of a disease chosen among the group consisting of asthma, acute and chronic inflammatory diseases, digestive tract motility disorders, endocrine disorders including diabetes, low blood pressure,  
25 graft-vs-host disease or tissue rejection, cancer, sexual impotence or a mixture thereof.

"A selective ligand of a VIP<sub>2</sub> receptor" means a compound having a higher selectivity for the VIP<sub>2</sub> receptor than for the VIP<sub>1</sub> receptor, preferably the  
30 mammalian VIP<sub>2</sub> receptor more specifically the human VIP<sub>2</sub> receptor.

It is meant by a "higher selectivity for the VIP<sub>2</sub> receptor than for the VIP<sub>1</sub> receptor" a ligand being 10-fold more selective for the VIP<sub>2</sub> receptor than for the VIP<sub>1</sub> receptor, preferably more than 100-fold more selective  
5 for the VIP<sub>2</sub> receptor than for the VIP<sub>1</sub> receptor, more preferably more than 1000 fold more selective for the VIP<sub>2</sub> receptor than for the VIP<sub>1</sub> receptor.

Said selective ligand of the VIP<sub>2</sub> receptor is an agonist wherein R<sub>1</sub> = Ac-His, R<sub>2</sub> = D-Phe, R<sub>3</sub> = Asp,  
10 R<sub>4</sub> = Ala or Gly, R<sub>5</sub> = Xaa, R<sub>6</sub> = Phe, R<sub>7</sub> = Xaa, R<sub>8</sub> = Glu, R<sub>9</sub> = Asn or Glu, R<sub>10</sub> = Tyr, R<sub>11</sub> to R<sub>14</sub> = Xaa, R<sub>15</sub> = Lys, R<sub>16</sub> = Arg or Gln, R<sub>17</sub> to R<sub>22</sub> = Xaa, R<sub>23</sub> = Leu, R<sub>24</sub> to R<sub>29</sub> = Xaa.

According to the invention, said selective  
15 ligand of the VIP<sub>2</sub> receptor is a peptidic ligand chosen among the group consisting of the RO 25-1553 whose formula is Ac-HSDAVFTENYTKLRKQ(Nle)AAKKYLNDLKKGGT-NH<sub>2</sub>, the PG-249a whose formula is Ac-HSDAVFTENYTKLRKQ(Nle)AAKKYLNDLKKGGT-NH<sub>2</sub> and the PG-249b whose formula is  
20 Ac-HSDAVFTENYTKLRKQ(Nle)AAK(Nle)YLNNLKKGGT-NH<sub>2</sub>.

This selective ligand of the VIP<sub>2</sub> receptor can be labelled as above-described for the ligand of the VIP<sub>1</sub> receptor and can be included in a pharmaceutical composition with an adequate pharmaceutical carrier as  
25 above-described.

This compound can also be included in a diagnostic device such as a diagnostic kit for the identification of the above-mentioned diseases or used as a specific tumours marker.

The present invention will be further described in connection with the following examples and which are presented for the purpose of illustration only.

5 **Brief description of the drawings**

Figure 1 represents amino acids comparative sequences of VIP, [L<sup>27</sup>]GRF(1-29), PG-97-268 and PG-97-269. The differences with the sequence of VIP were surrounded.

10 Figure 2 represents a summary of the binding studies of the VIP and PG-97-268 on the different receptors subtype tested.

Figure 3 represents a summary of the binding studies of the VIP and PG-97-269 on the different receptor subtypes tested.

15 Figure 4 represents amino acids comparative sequences of VIP and RO 25-1553. The differences between sequences are surrounded.

Figure 5 represents a summary of selective VIP<sub>2</sub> ligands on the different receptor subtypes tested.

**Example 1**

**Materials and methods**

**Cell lines used for receptor characterisation**

25 The DNA coding for the rat secretin receptor [2,15], the PACAP type I receptor [5,16] and the PACAP type II VIP<sub>1</sub> and VIP<sub>2</sub> receptors [3,17,30] were cloned into a mammalian expression vector containing the selectable neomycin phosphotransferase gene. The resulting recombinant  
30 plasmids were transfected into the CHO cell line DG44 by electroporation using a gene pulser. The selection of the

clones as well as their main characteristics have already been published [2,3,5,30].

Cells were maintained in  $\alpha$ -minimal essential medium ( $\alpha$ MEM), supplemented with 10% foetal calf serum, 5 2 mM L-glutamine, 100  $\mu$ g/ml penicillin and 100  $\mu$ g/ml streptomycin with an atmosphere of 95% air, 5% CO<sub>2</sub> at 37 °C. Geneticin (0.5 mg/ml) was maintained in the culture medium of the stock culture. Subcultures prepared for membrane purification were done in a medium without 10 geneticin.

LoVo cell line was obtained from ATCC (Rockville, M.D.) and cultured in Eagle's minimal essential medium (GIBCO, Gent, Belgium) supplemented with 5% foetal calf serum, 0.6 mg/ml glutamine, 200 IU/ml penicillin and 15 100  $\mu$ g/ml streptomycin.

#### **Membrane preparation, receptor identification and adenylate cyclase activity determination**

Cells were harvested with a rubber policeman 20 and pelleted by low speed centrifugation; the supernatant was discarded and the cells lysed in 1 mM NaHCO<sub>3</sub> and immediate freezing in liquid nitrogen. After thawing, the lysate was first centrifuged at 4 °C for 10 min at 400 x g and the supernatant was further centrifuged at 20 000 x g 25 for 10 min. The pellet, resuspended in 1 mM NaHCO<sub>3</sub>, was used immediately on a crude membrane preparation. [<sup>125</sup>I]VIP (specific radioactivity of 0.7 mCi/mmol), [<sup>125</sup>I]Ac-His<sup>1</sup>-PACAP-27 (specific radioactivity of 0.5 mCi/mmol) and [<sup>125</sup>I]secretin (specific radioactivity of 0.3 mCi/mmol) were

obtained as described previously [2,3,5]. Binding of the tracers to membranes was performed as described [2,3,5].

In all cases, the non-specific binding was defined as the residual binding in the presence of 1  $\mu$ M of the unlabelled peptide corresponding to the tracer.

Adenylate cyclase activity was determined by the Salomon et al. method [18] as previously described [6].

### Peptide synthesis

All peptides were synthesised as C-terminal amides by solid phase methodology on an Automated Applied Biosystems apparatus using the Fmoc (9-fluorenylmethoxycarbonyl) strategy as previously described [6].

The peptides were cleaved and purified by reverse phase chromatography on DVB 300Å (10 x 1 cm) and by ion exchange chromatography on Mono S HR 5/5. The peptide purity was assessed (95%) by capillary electrophoresis and the sequence conformity was verified by direct sequencing and ion spray mass spectrometry.

### Results

#### Preliminary studies on the potency and selectivity of rabbit secretin

Rabbit secretin or [L<sup>6</sup>, R<sup>16</sup>, L<sup>27</sup>] secretin bound to the rat secretin receptor with a 6-fold lower affinity than secretin. [L<sup>6</sup>] secretin was indistinguishable from rabbit secretin while [R<sup>16</sup>] secretin was 2-fold less potent than secretin.

[L<sup>6</sup>, R<sup>16</sup>, L<sup>27</sup>] secretin had a 3-fold higher affinity than secretin for the rat VIP<sub>1</sub> receptor. Single



substitutions in positions 6 and 16, respectively, had opposite effects : [L<sup>6</sup>] secretin had a 3-fold lower affinity and [Arg<sup>16</sup>] secretin a 20 fold higher affinity than secretin for the VIP<sub>1</sub> receptor. Thus, rabbit secretin  
5 was more VIP-like than secretin and this preference was due to the substitution of Ser by Arg in position 16.

Properties of [R<sup>16</sup>] VIP and [R<sup>16</sup>] PACAP

[R<sup>16</sup>] VIP and [R<sup>16</sup>] PACAP had a 4-fold higher  
10 affinity than VIP and PACAP for the VIP<sub>1</sub> receptor and a 10- and 4-fold higher affinity for the PACAP I receptor. [R<sup>16</sup>] secretin was also more potent than secretin on the PACAP receptor but the effect of Ser-Arg replacement could not be evaluated quantitatively, due to the low affinity of  
15 secretin for that receptor.

Thus, incorporation of Arginine in position 16 of secretin, VIP and PACAP increased the peptides affinities for VIP<sub>1</sub> and PACAP receptors.

Furthermore, [R<sup>16</sup>] VIP and [R<sup>16</sup>] PACAP had a  
20 lower affinity than VIP and PACAP for the secretin receptor.

The [R<sup>16</sup>] substituted secretin, VIP and PACAP were also tested for their capability to stimulate adenylate cyclase activity. The dose-effect curves obtained  
25 on the three recombinant receptors confirmed the binding data : in cell membranes expressing the secretin receptor, [R<sup>16</sup>] secretin, [R<sup>16</sup>] VIP and [R<sup>16</sup>] PACAP were 2.5, 6.0 and 3.0 fold less potent than the corresponding unsubstituted peptides; in cell membranes expressing the VIP<sub>1</sub> receptor,  
30 [R<sup>16</sup>] secretin, [R<sup>16</sup>] VIP and [R<sup>16</sup>] PACAP were 10, 3 and 2

fold more potent than the unsubstituted peptides; and in cell membranes expressing the PACAP receptor, [R<sup>16</sup>] secretin, [R<sup>16</sup>] VIP and [R<sup>16</sup>] PACAP were respectively 8, 4 and 2 fold more potent than the unsubstituted peptides.

5           The Inventors first observed that rabbit secretin was less potent than porcine secretin on rat secretin receptors but more potent on VIP<sub>1</sub> receptors. Rabbit secretin differs from porcine secretin in positions 6, 16 and 27 [14]. Substitution of the C-terminal Val<sup>27</sup>-NH<sub>2</sub>  
10 by Leu<sup>27</sup>-NH<sub>2</sub> was not investigated directly as it was considered of limited consequence : indeed, both amino acids were hydrophobic and the C-terminal 20-27 part of secretin can be replaced by the 20-27 sequence of PACAP without any modification of peptide potency. Introduction  
15 of a Leu- instead of a Phe residue in position 6 of secretin decreased markedly the peptide potency on both rat secretin and VIP<sub>1</sub> receptors. Phe<sup>6</sup>, that is conserved in all members of the VIP/Sn/glucagon family of peptides, is usually considered as essential for biological activity :  
20 [Tyr<sup>6</sup>] secretin displayed 1% of the secretin activity [19], [D-Phe<sup>6</sup>] secretin was inactive in in vivo models [20] and 300-fold less active than secretin in rat cardiac membranes [21], [hexahydro-Phe<sup>6</sup>] secretin had also a reduced activity both in vivo and in vitro [20].

25           Introduction of Arg<sup>16</sup> instead of Ser in secretin or Gln in VIP and PACAP decreased the peptides affinities for the secretin receptor but increased their affinities for the VIP<sub>1</sub> and PACAP receptors. These results were rather unexpected as position 16 has never been  
30 considered as important for secretin, VIP<sub>1</sub> or PACAP

receptor recognition. In both VIP and PACAP molecules, it is assumed that, followed a  $\beta$ -turn involving residues 7 to 10, the peptides adopt a continuous  $\alpha$ -helix conformation [12,22,23] or two helical structures separated by an unidentified structure between amino acids 14 to 21 [12,24]. In secretin however, Ser<sup>16</sup> is thought to be involved in the 13-16 reverse turn connecting the two  $\alpha$ -helix structures 7 to 11 and 17 to 24 [24]. It is possible that the introduction of a charged amino acid in position 16 disturbs the peptides structures.

The increased affinity of the three Arg<sup>16</sup> peptides for the VIP<sub>1</sub> and PACAP receptors could result either from the introduction of a new bond between the receptor and the ligand or from stabilisation of a ligand conformation that fits better in the binding pocket of the receptor.

Whatever the explanation, it appears that Arg<sup>16</sup> interacts with the N-terminal domain of the secretin and the VIP<sub>1</sub> receptors : indeed, the chimeric receptors having only the N-terminal domain of secretin or VIP behave like the entire secretin and VIP<sub>1</sub> receptors, respectively.

Due to their potential application in human therapy, and particularly in asthma, VIP analogues with a high stability and affinity have been developed : the combination of a C-terminal extension that stabilises the terminal  $\alpha$ -helix, of N-acetylation and of cyclisation between positions 21 to 25 led to the RO 25-1553 compound that was 10-fold more potent than VIP for tracheal smooth muscle relaxation [25]. The introduction of an Arg<sup>16</sup> residue results in a further increase in peptide bioactivity.

Table 1

Amino acid sequence of the peptides tested.

All the peptides were carboxy terminally amidated.

	1	5	10	15	20	25																							
5	VIP	H	S	D	A	V	F	T	D	N	Y	T	R	L	R	K	Q	M	A	V	K	K	Y	L	N	S	I	L	N
	PACAP	H	S	D	G	I	F	T	D	S	Y	S	R	Y	R	K	Q	M	A	V	K	K	Y	L	A	A	V	L	
	pSn*	H	S	D	G	T	F	T	S	E	L	S	R	L	R	D	S	A	R	L	Q	R	L	L	Q	G	L	V	
	rabSn*	H	S	D	G	T	L	T	S	E	L	S	R	L	R	D	R	A	R	L	Q	R	L	L	Q	G	L	L	
	[L <sup>6</sup> ] Sn	H	S	G	D	T	L	T	S	E	L	S	R	L	R	D	S	A	R	L	Q	R	L	L	Q	G	L	V	
10	[R <sup>16</sup> ] Sn	H	S	D	G	T	F	T	S	E	L	S	R	L	R	D	R	A	R	L	Q	R	L	L	Q	G	L	V	

\* : pSn = porcine secretin

rabSn = rabbit secretin = [L<sup>6</sup>, R h16, L<sup>27</sup>]pSn

Example 215 Materials and methods

**Peptide synthesis, cell culture and membrane preparation**

The ligands VIP, PG-97-268 and PG-97-269 were synthesised as described in example 1.

Chinese hamster ovary cells (CHO cells) expressing the recombinant rat VIP<sub>1</sub> receptor (3), the rat VIP<sub>2</sub> receptor; the human VIP<sub>2</sub> receptor (30) and the rat PACAP type I receptor (5); the rat secretin receptor were maintained as described in the example 1.

25 **Receptor identification and adenylate cyclase activation**

The membrane and tracer were prepared as described in the example 1. Binding of the tracer to membrane was performed as described [2,3,5].

Adenylate cyclase activity was determined by the Salomon et al. procedure (18) as previously described (6).

## **Results**

### **Characteristics of the cell lines**

The characteristics of the CHO cell lines transfected with the DNA coding for the rat VIP<sub>1</sub>-, human VIP<sub>2</sub>- and rat PACAP type I receptors were the following :  
5 the VIP<sub>1</sub> r clone 3 and 16 expressed, respectively,  $850 \pm 50$  and  $100 \pm 30$  fmol of rat VIP<sub>1</sub> receptor/mg protein (3); the VIP<sub>2</sub> r clone 11 expressed  $210 \pm 40$  fmol of human VIP<sub>2</sub> receptor/mg protein (30) and the PACAP I r clone P2-10  
10 expressed  $4.6 \pm 0.3$  pmol of rat PACAP I receptor/mg protein (5). mRNA was prepared from LoVo cells, reverse transcribed into cDNA and tested by polymerase chain reaction with appropriate primers for the presence of VIP<sub>1</sub>-, VIP<sub>2</sub>- and PACAP I receptors cDNA : VIP<sub>1</sub> receptor  
15 mRNA was only detected in LoVo cells. The Sn r clone 5 expressed  $450 \pm 80$  fmol/mg protein (2).

### **Comparative effects of VIP, PG-97-268 and PG-97-269 on receptor occupation and adenylate cyclase activation**

20 On CHO cell membranes expressing the rat VIP<sub>1</sub> recombinant receptor, VIP and the agonist PG-97-268 had an identical  $IC_{50}$  value of 2.0 nM but on the rat VIP<sub>2</sub> recombinant receptor, PG-97-268 was poorly recognised with a  $IC_{50}$  value of 30000 nM.

25 An identical selective profile was obtained when we measured the inhibition of the tracer binding on the membranes expressing the human VIP<sub>1</sub> and VIP<sub>2</sub> receptors with  $IC_{50}$  values of 1 and 30000 nM, respectively for the PG-97-268.

The same selectivity was observed when measuring adenylate cyclase activity in the clone expressing the rat VIP<sub>1</sub> recombinant receptor and in the LoVo cells expressing the human VIP<sub>1</sub> receptor. The VIP/GRF  
5 hybrid stimulated adenylate cyclase activity maximally.

PG-97-268 had negligible affinities for the rat PACAP and secretin receptors.

The antagonist PG-97-269 had a good affinity for the rat VIP<sub>1</sub> recombinant receptor (Ic<sub>50</sub> : 10 nM) and  
10 the same affinity as VIP for the human VIP<sub>1</sub> receptor (Ic<sub>50</sub> : 2 nM). This VIP/GRF hybrid poorly recognised the rat VIP<sub>2</sub> and the human VIP<sub>2</sub> receptors with Ic<sub>50</sub> values of 2000 and 3000 nM, respectively.

PG-97-269, tested at a concentration up to  
15 10000 nM, did not stimulate adenylate cyclase activity of any membrane preparation. PG-97-269 inhibited dose-dependently and competitively the stimulatory effect of VIP on cell membranes expressing the rat and the human VIP<sub>1</sub> receptors. The Ki values obtained were 15 and 2 nM for the  
20 rat and human VIP<sub>1</sub> receptors, respectively. PG-97-269 had negligible interactions with the rat PACAP and secretin receptors.

VIP/PACAP receptors are classified as PACAP type I receptors that had a high affinity for PACAP and a  
25 low affinity for VIP and PACAP type II receptors that had an equal high affinity for PACAP and VIP. The PACAP type II receptors were further subdivided into VIP<sub>1</sub> and VIP<sub>2</sub> receptors (34, 35). VIP<sub>1</sub> receptors have been cloned in rat (17) and human (26), VIP<sub>2</sub> receptors have been cloned in rat  
30 (28), mouse (29) and human (30). The VIP<sub>2</sub> receptor

corresponds to the "helodermin-preferring" receptor previously described on the basis of the relative potency of natural and synthetic analogues of VIP (31, 33).

In situ hybridisation to rat organs revealed  
5 the expression of VIP<sub>1</sub> receptor mRNA (36) in lung large and moderate size bronchi, small intestine, thymus, liver, adrenal medulla, uterine smooth muscle and within the brain in the cerebral cortex and hippocampus. VIP<sub>1</sub> receptor mRNA was expressed in human epithelial cell lines (37), rat  
10 pituitary cells and tumours (38) and occasionally in human brain tumours (39) and neuroblastomas (40).

The Inventors found that the new ligands PG-97-268 and PG-97-269 are highly selective agonist and antagonist of the VIP<sub>1</sub> receptor. Their IC<sub>50</sub> values for the  
15 VIP<sub>1</sub> receptor are in the nanomolar range, as opposed to the range of 2000 - 3000 nM for the VIP<sub>2</sub> receptor.

In addition, the PG-97-268 is as efficient as VIP on the VIP<sub>1</sub> receptor and PG-97-269 is more efficient on the human VIP<sub>1</sub> receptor than on the rat VIP<sub>1</sub> receptor.

20 Both molecules did not recognise the PACAP I receptor and also the secretin receptor and recognised poorly the VIP<sub>2</sub> receptor.

PG-97-268 was a full agonist on the adenylate cyclase activity. The EC<sub>50</sub> values calculated from the  
25 adenylate cyclase activity studies were in agreement with the IC<sub>50</sub> values obtained from the binding studies.

The introduction of an acetyl in position 1 and a D-Phe residue in position 2 led to an antagonist compound. PG-97-269 did not stimulate the adenylate  
30 cyclase.

Diarrhoea and hypotension are the most likely side effects expected from a systemic administration of VIP or analogues (41). Diarrhoea is mediated through interaction of VIP with the enterocytes VIP<sub>1</sub> receptor (42).

5 The receptor subclass that mediates the vascular bed relaxation is not known : pharmacological studies based on the relative potency of N-terminally modified VIP analogues suggest however that these receptors are different from the liver and brain (VIP<sub>1</sub> and PACAP I) receptors (43). Besides

10 its potential therapeutic value, PG-97-268 appears to be the best tool with the RO-25-1553 (Patent EP-96870121.9) available to evaluate the contribution of each receptor subclass to a VIP mediated response.

15 Example 3

Materials and methods

**Peptide synthesis and cell culture**

VIP, PACAP-27 and PACAP-38 , PG96-249a and PG96-249b were synthesised as described in example 1.

20 Chinese hamster ovary cells (CHO cells) expressing the recombinant rat VIP<sub>1</sub> receptor (47), the human VIP<sub>2</sub> receptor (30) and the rat PACAP type I receptor (8) were maintained in as described in the example 1.

HCT 15 and LoVo cell lines (human

25 adenocarcinoma from the colon) were obtained from ATCC (Rockville, M.D.) and cultured as in the example 1.

The SUP T1 lymphoblastic cell line was cultured in RPMI medium supplemented with 5% foetal calf serum.



The membrane preparation, receptor identification and adenylate cyclase activation were performed as described in example 1.

## 5 **Results**

### **Characteristics of the cell lines**

The characteristics of the CHO cell lines transfected with the DNA coding for the rat VIP<sub>1</sub> and human VIP<sub>2</sub> receptors were the following : the VIP<sub>1</sub> r clone 3 and  
10 16 expressed, respectively,  $850 \pm 50$  and  $100 \pm 30$  fmol of rat VIP<sub>1</sub> receptor/mg protein (47) and the VIP<sub>2</sub> r clone 11 expressed  $210 \pm 40$  fmol of human VIP<sub>2</sub> receptor/mg protein (30). mRNA was prepared from SUP T1-, HCT 15 and LoVo cells, reverse transcribed into cDNA and tested by  
15 polymerase chain reaction with appropriate primers for the presence of VIP<sub>1</sub>- and VIP<sub>2</sub>- receptors cDNA : VIP<sub>2</sub> receptor mRNA only was detected in SUP T1 cells and VIP<sub>1</sub> receptor mRNA only in HCT 15 and LoVo cells.

### 20 **Comparative effects of VIP, PACAP-27 and RO 25-1553 on receptor occupation and adenylate cyclase activation**

On CHO cell membranes expressing the rat VIP<sub>1</sub> recombinant receptor, the competition curves of <sup>125</sup>I-VIP binding inhibition were identical for the two clones  
25 studied. VIP and PACAP-27 had an identical IC<sub>50</sub> value of 1.0 nM and RO 25-1553 was 100-fold less potent (IC<sub>50</sub> value of 100 nM). An identical selectivity profile was observed when measuring adenylate cyclase activity : in the clone expressing the highest receptor number and characterised by  
30 low EC<sub>50</sub> value due to an amplification process linked to an

"excess" of receptors and in the clone expressing a lower receptor density, RO 25-1553 was 100-fold less potent than VIP and PACAP-27.

On CHO cell membranes expressing the human  
5 recombinant VIP<sub>2</sub> receptor, VIP and PACAP-27 were also  
equipotent but 3- to 10-fold less potent than RO 25-1553 to  
inhibit tracer binding and to stimulate adenylate cyclase  
activity. On CHO cell membranes expressing a high number of  
rat recombinant PACAP type I receptors (P2-10 cells), VIP  
10 was 300-fold less potent than PACAP-27 and 10-fold more  
potent than RO 25-1553.

On LoVo cell membranes that express the human  
VIP<sub>1</sub> receptor, PACAP-27 and VIP were equipotent and  
600-fold more potent than RO 25-1553. RO 25-1553 had a  
15 lower efficacy than VIP on adenylate cyclase activity  
stimulation. <sup>125</sup>I-VIP binding could not be valuably studied  
on HCT 15 cell membranes (expressing the human VIP<sub>1</sub>  
receptor), due probably to a low receptor density. However,  
a VIP stimulated adenylate cyclase activity was measurable.  
20 RO 25-1553 was a weak stimulant. As expected for a partial  
agonist, the EC<sub>50</sub> value of VIP was increased in the  
presence of a high RO 25-1553 concentration.

On SUP T1 cell membranes, that express the  
human VIP<sub>2</sub> receptor, the results were comparable to those  
25 obtained on CHO cells expressing the recombinant VIP<sub>2</sub>  
receptor : VIP and PACAP had a comparable potency lower  
than that of RO 25-1553.

VIP/PACAP receptors are classified as PACAP  
type I receptors that had a high affinity for PACAP and a  
30 low affinity for VIP and PACAP type II receptors that had  
an equal high affinity for PACAP and VIP. The PACAP type II

receptors were further subdivided into VIP<sub>1</sub> and VIP<sub>2</sub> receptors (34, 35). VIP<sub>1</sub> receptors have been cloned in rat (48) and human (26), VIP<sub>2</sub> receptors have been cloned in rat (28), mouse (29) and human (30). The VIP<sub>2</sub> receptor  
5 corresponds to the "helodermin-preferring" receptor previously described on the basis of the relative potency of natural and synthetic analogues of VIP (31, 33). Pharmacological studies performed on cell lines previously identified VIP<sub>2</sub> receptors in T lymphoblast cells (31, 49,  
10 50), in a monocytic cell line (51) and in lung cancer derived cell lines (52). The mapping of the distribution of the mRNA coding for the VIP<sub>2</sub> receptor has been performed recently in rat tissues (53). The mRNA receptor is located in discrete brain areas, in neuroendocrine tissues, in the  
15 stomach, in testis (54) but also in the terminal bronchioles. Its distribution is complementary to that of the VIP<sub>1</sub> receptor.

The Inventors found that the ligand RO 25-1553 is a highly selective agonist of the VIP<sub>2</sub>  
20 receptor : its IC<sub>50</sub> value for the recombinant and the SUP T1 VIP<sub>2</sub> receptor is approximately 0.3 nM, as opposed to 100 to 600 nM for the VIP<sub>1</sub> receptor and > 10 µM for the PACAP I and secretin receptors. RO 25-1553 is as efficient as VIP on the VIP<sub>2</sub> receptor and on the rat recombinant VIP<sub>1</sub>  
25 receptor but less efficient on the human VIP<sub>1</sub> receptor. Furthermore, this analogue had a lower affinity than VIP on the PACAP I receptor and also on the secretin receptor. RO 25-1553 was much more selective than the lizard peptide helodermin that previously served as reference for the  
30 discrimination between VIP<sub>1</sub> and VIP<sub>2</sub> receptors. The IC<sub>50</sub>

values of helodermin were indeed of 2 nM (7), 30 nM (6), 1000 nM (24) and 40 nM (25) for the VIP<sub>2</sub>-, the VIP<sub>1</sub>-, the PACAP I- and the secretin receptors, respectively.

The molecular basis for the high selectivity  
5 of RO 25-1553 is still speculative but several chemical modifications could participate : acetylation of the NH<sub>2</sub>-terminus of VIP was already reported to increase peptide affinity for the VIP<sub>2</sub> receptor (33); a glutamic acid in position 8 (instead of aspartic acid in VIP) is  
10 also present in helodermin (57); increasing the C-terminal end of PACAP-27 derivatives led to partial agonists and antagonists with a higher affinity for the VIP<sub>2</sub>- than for the VIP<sub>1</sub> receptors (58).

The present findings were unexpected  
15 considering the pharmacological profile of the ligand RO 25-1553 : in vitro, the ligand RO 25-1553 was more potent than the ligand VIP as a relaxant of isolated guinea pig tracheal - and human bronchial smooth muscle; in vivo, administered by endotracheal instillation or by  
20 aerosolisation RO 25-1553 is also more potent than VIP (25). Part of the difference between the ligands VIP and RO 25-1553 may be explained by an increased stability of the analogue. One should keep in mind however the fact that the distribution of VIP<sub>1</sub> and VIP<sub>2</sub> receptors in guinea pig  
25 and human lung has not been studied. In rat, as already mentioned, VIP<sub>1</sub> receptor mRNA was observed in the proximal bronchi and in the mucosa cells, and the VIP<sub>1</sub> receptors mRNA in the distal bronchioles.

The ligand RO 25-1553 also prevented lung  
30 inflammation during an antigen-induced pulmonary anaphylaxis; its effects on oedema, and eosinophilic

mobilisation in alveolar fluid were not reproduced by VIP (46). In that case also, the stability of the ligand RO 25-1553 could be of importance. Furthermore, VIP<sub>1</sub> receptors were identified in cells involved in immunity and  
5 inflammation (49).

Diarrhoea and hypotension are the most likely side effects expected from a systemic administration of VIP or analogues (41). Diarrhoea is mediated through interaction of VIP with the enterocytes VIP<sub>1</sub> receptor (42).  
10 The receptor subclass that mediates the vascular bed relaxation is not known : pharmacological studies based on the relative potency of N-terminally modified VIP analogues suggest however that these receptors are different from the liver and brain (VIP<sub>1</sub> and PACAP I) receptors (43). Besides  
15 its potential therapeutic value, the ligand RO 25-1553 appears to be the best tool available to evaluate the contribution of each receptor subclass to a VIP mediated response.

Similar results were obtained with the ligands PG96-249a and PG96-249b ( see Figure 5 enclosed).

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CLAIMS

1. Peptidic ligand having a higher selectivity for the VIP<sub>1</sub> receptor than for the VIP<sub>2</sub> receptor.
- 5 2. Ligand according to the claim 1, having a 100-fold higher selectivity for the VIP<sub>1</sub> receptor than for the VIP<sub>2</sub> receptor.
3. Ligand according to the claim 1 or 2, having a 1000-fold higher selectivity for the VIP<sub>1</sub> receptor  
10 than for the VIP<sub>2</sub> receptor.
4. Ligand according to any of the preceding claims, wherein the VIP<sub>1</sub> receptor is a mammalian receptor, preferably a human receptor.
5. Ligand according to any of the preceding  
15 claims, having in position 16 (R<sub>16</sub>) a basic amino acid.
6. Ligand according to the claim 5, wherein the basic amino acid in position 16 is the Arginine (Arg).
7. Ligand according to the claim 5 or 6, having in position 4 (R<sub>4</sub>) an amino acid chosen among the  
20 group consisting of Ala, Gly, D-Ala or D-Phe.
8. Ligand according to any of the preceding claims, which is an agonist wherein R<sub>1</sub> = His, R<sub>2</sub> = Ser, R<sub>3</sub> = Asp, R<sub>4</sub> = Xaa, Ala, D-Ala or Gly, R<sub>5</sub> = XAA, R<sub>6</sub> = Phe, R<sub>7</sub> to R<sub>9</sub> = Xaa, R<sub>10</sub> = Tyr, R<sub>11</sub> to R<sub>14</sub> = Xaa, R<sub>15</sub> = Lys,  
25 R<sub>16</sub> = Arg, R<sub>17</sub> to R<sub>22</sub> = Xaa, R<sub>23</sub> = Leu, R<sub>24</sub> to R<sub>25</sub> = Xaa, R<sub>26</sub> and R<sub>27</sub> = Xaa or are deleted.
9. Ligand according to any of the preceding claims, characterised in that it is an agonist having the following formula : H-S-D-A-V-F-T-N-S-Y-R-K-V-L-K-R-L-S-A-  
30 R-K-L-L-Q-D-I-L-NH<sub>2</sub>.

10. Ligand according to the claim 8 or 9, having an  $IC_{50}$  affinity value  $\leq 30$  nM for the  $VIP_1$  receptor, preferably the human  $VIP_1$  receptor.

11. Ligand according to any of the claims 1  
5 to 7, being an antagonist wherein  $R_1 = \text{Ac-His}$ ,  $R_2 = \text{D-Phe}$ ,  $R_3 = \text{Asp}$ ,  $R_4 = \text{Xaa}$ , Ala, D-Ala or Gly,  $R_5 = \text{Xaa}$ ,  $R_6 = \text{Phe}$ ,  $R_7$  to  $R_9 = \text{Xaa}$ ,  $R_{10} = \text{Tyr}$ ,  $R_{11}$  to  $R_{14} = \text{Xaa}$ ,  $R_{15} = \text{Lys}$ ,  $R_{16} = \text{Arg}$ ,  $R_{17}$  to  $R_{22} = \text{Xaa}$ ,  $R_{23} = \text{Leu}$ ,  $R_{24}$  to  $R_{25} = \text{Xaa}$ ,  $R_{26}$  and  $R_{27} = \text{Xaa}$  or are deleted

12. Ligand according to any of the claim 11, having the following formula :  $\text{Ac-H-(D-Phe)-D-A-V-F-T-N-S-Y-R-K-V-L-K-R-L-S-A-R-K-L-L-Q-D-I-L-NH}_2$ .

13. Ligand according to the claim 11 or 12, having an  $IC_{50}$  affinity value  $\leq 100$  nM for the  $VIP_1$   
15 receptor, preferably for the human  $VIP_1$  receptor.

14. Ligand according of any of the preceding claims, being labelled.

15. Ligand according to the claim 14, wherein the compound is labelled by a radio-active marker.

16. Ligand according to any of the claims 1  
20 to 14, for use as a therapeutic agent.

17. Ligand according to any of the claims 1 to 14, for the treatment of a disease chosen among the group consisting of bronchoconstrictive disorders such as  
25 asthma, COPD, tumours such as neuroendocrine, gastroenteropancreatic or colon tumours, myocardial infarctions and strokes, gastroenterological diseases having dysfunctions of motility, auto-immune diseases, side-effects of organs transplantations, inflammations.

18. Ligand according to any of the claims 1 to 14, for the regeneration of the nerves, or for the increasing of the cells growth.

19. Ligand according to any of the claims 1 to 14, as anti-oxidant or anti-inflammatory compound.

20. Pharmaceutical composition comprising the ligand according to any of the claims 1 to 14 and a pharmaceutically acceptable carrier material.

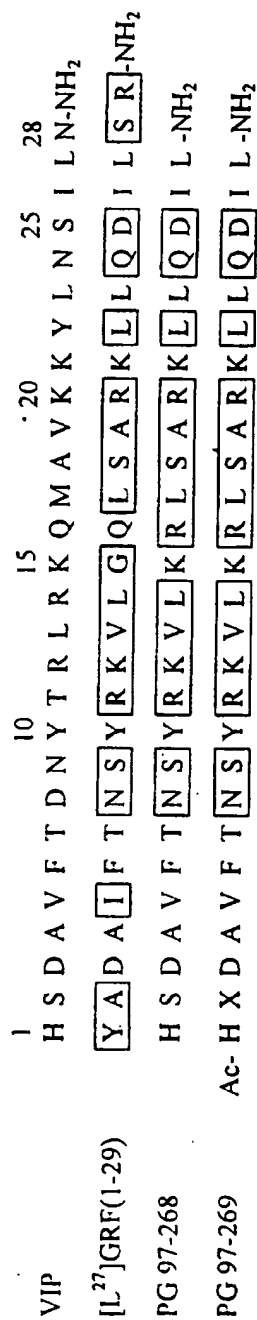
21. Diagnostic device which comprises the ligand according to the claim 14 or 15.

22. Method for recovering a compound not known to be capable of specifically binding as an antagonist or as an agonist to a VIP<sub>1</sub> receptor, preferably a mammal receptor, more specifically a human receptor, can specifically bind to said receptor, which comprises contacting a cell, preferably a mammalian cell or a cell extract from said cell, comprising a vector adapted for expression in said cell, which vector further comprises nucleic acid molecule which expresses said VIP<sub>1</sub> receptor on the cell's surface, possibly isolating a membrane fraction from the cell extract and incubing the ligand according to any of the preceding claims 1 to 13 with said cell or cell extract under conditions permitting binding of the ligand to the receptor, and with the compound, and detecting the presence of any bound compound with the VIP<sub>1</sub> receptor and recovering said compound.

23. Compound identified by the method according to the claim 22.

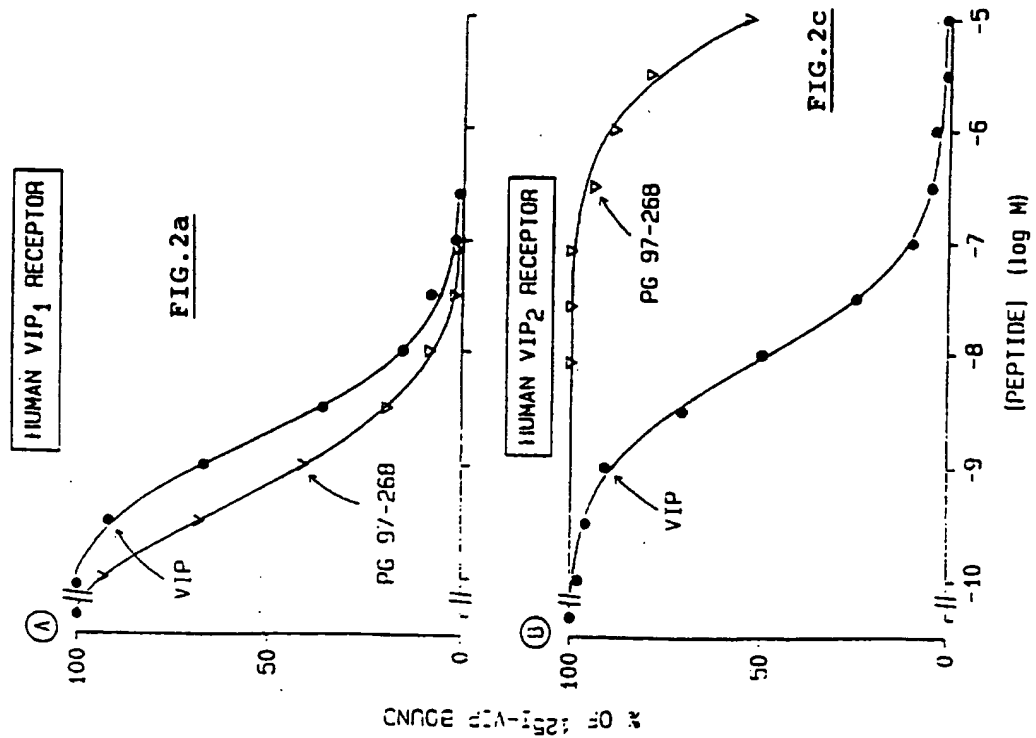
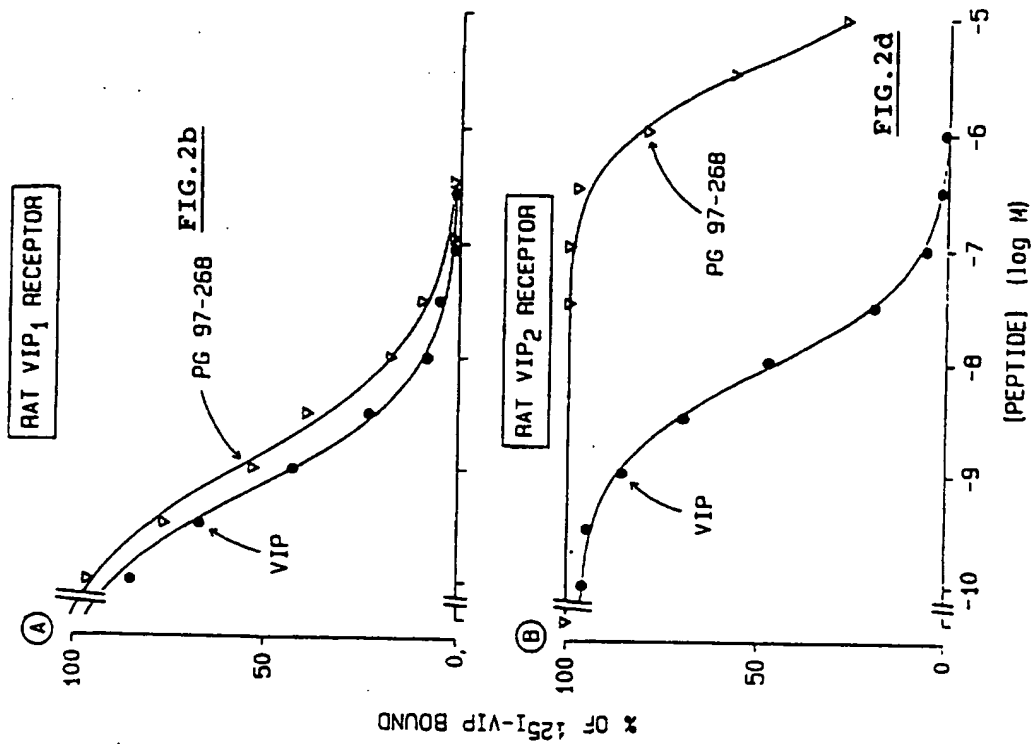
24. Pharmaceutical composition comprising the compound according to the claim 23 and a pharmaceutically acceptable carrier.

FIG. 1

Ac = N<sup>α</sup> acetyl

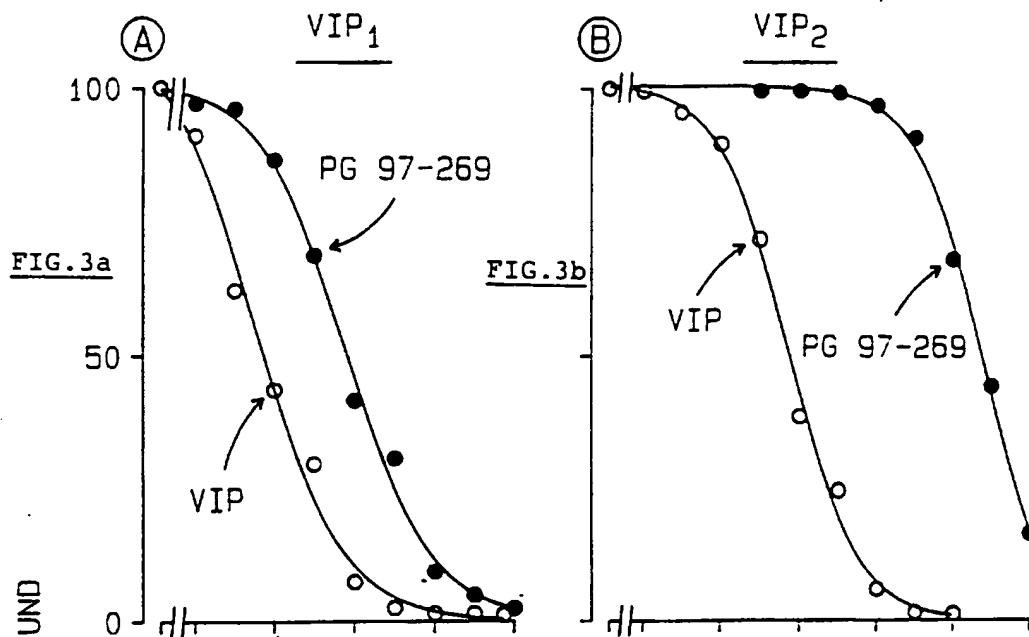
X = D-Phe

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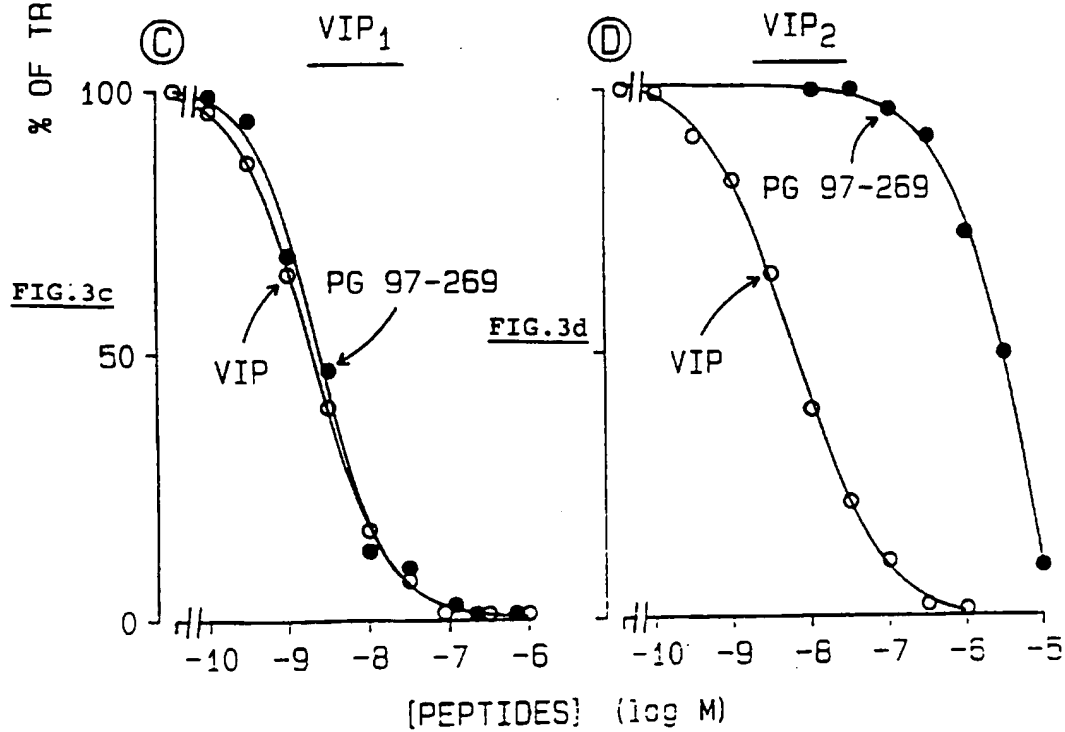


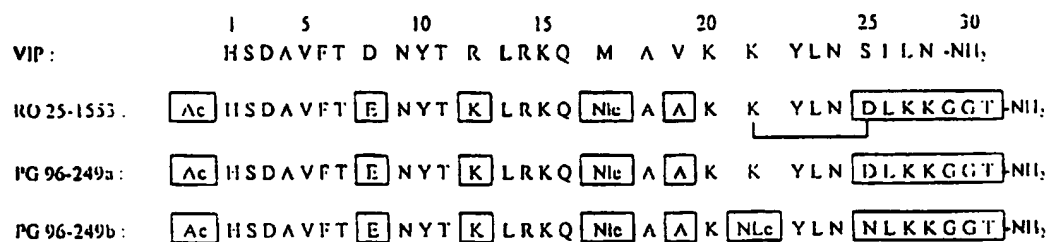
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## RAT RECEPTORS



## HUMAN RECEPTORS





Ac = N<sup>α</sup>acetyl; Nle = norleucine.

**FIG. 4**

IC<sub>50</sub> values (in nM)

	RAT VIP <sub>1</sub> R	RAT VIP <sub>2</sub> R	HUMAN VIP <sub>1</sub> R	HUMAN VIP <sub>2</sub> R
VIP	2	4	2	5
RO 25-1553	100	3	800	0.8
PG 96-249a	300	20	3000	10
PG 96-249b	300	20	3000	10

**FIG. 5**